

***Paraleucobryum* (Bryophyta: Bryopsida: Dicranaceae) in New Mexico**

Kelly W. Allred

Range Science Herbarium (NMCR), New Mexico State University, Las Cruces
kla49@outlook.com

Russ Kleinman

Department of Natural Sciences, Western New Mexico University, Silver City
sparks@zianet.com

The moss genus *Paraleucobryum* was created in 1907 when Leopold Loeske elevated *Dicranum* subgenus *Paraleucobryum* to generic rank (Loeske 1907). Its similarity to *Dicranum* is evident in its dense tuft- or cushion-forming growth, tomentose stems, often falcate leaves swept to one side, a single costa extending the length of the leaf, and conspicuously enlarged and often red-brown-orange alar cells. It differs conspicuously from *Dicranum* (s.s.), however, in having straight-erect capsules, a relatively broad costa ($\frac{1}{3}$ to equaling the blade width), and leaf cross-sections composed of three layers: an adaxial layer of hyaline cells, a middle layer of mostly chlorophyllose cells, and an abaxial layer of hyaline cells (these sometimes intermixed with chlorophyllose cells). After phylogenetic restructuring of the Dicranaceae (La Farge et al. 2000, 2002; Stech 1999), *Paraleucobryum* is the sole genus within that family with this unusual 3-layer arrangement. The genus comprises 3-4 species mostly in northern hemispheric regions of Asia, Europe, Mexico, and North America. The name *Paraleucobryum* connotes a similarity or comparison to *Leucobryum* (Greek *para*, by the side of, near, compared with, similar to, and *Leucobryum*).

Paraleucobryum enerve (Thedenius) Loeske has been consistently reported for New Mexico by all moss literature mentioning the state: first by Williams (1913), and then by Bartram (1931), Flowers (1971), Mahler (1978), Müller & Frahm (1987), and Ireland (1994, 2007). This species is identified by the generally straight leaves with entire margins, excessively broad costa, and smooth and non-ridged abaxial leaf surface.

Paraleucobryum longifolium Ehrhart ex Hedwig was first reported for New Mexico by Bartram (1931), and subsequently by Mahler (1978, based on Bartram 1931), Crum & Anderson (1981), Müller & Frahm (1987), Ireland (2007), and Allred (2011). The species is identified by the curving to falcate/circinate leaves with markedly serrate margins, moderately broad costa with the central cells commonly smaller than the adjacent surface cells, and ridged abaxial leaf surface.

Paraleucobryum sauteri (Bruch & Schimper) Loeske was first reported for New Mexico by Müller & Frahm (1987), and referenced for New Mexico by Ireland (2007) in his discussion of *P. longifolium*, within which he submerged *P. sauteri*. This species is identified by the curving to falcate/circinate leaves with entire or serrulate margins, relatively narrow costa with the central cells commonly larger than the adjacent surface cells, and weakly to moderately ridged abaxial leaf surface.

Table 1 summarizes the features of *Paraleucobryum enerve*, *P. longifolium*, and *P. sauteri*, as gleaned from pertinent literature and study of specimens (see Appendix I).

Paraleucobryum longifolium* and *P. sauteri

The relationship of *Paraleucobryum longifolium* and *P. sauteri* has been muddled throughout their histories. Early on, *sauteri* was considered a separate and valid species, then a subspecies of *longifolium*, a variety of *longifolium*, or submerged within *longifolium* without rank. In more recent times, though, European and Asian workers have consistently distinguished *P. longifolium* and *P. sauteri* at the species level (see Gao et al. 1999; Hallingbäck et al. 2006; Müller & Frahm 1987; Nyholm 1954).

In North America, Williams (1913), in his landmark study of Dicranaceae for Canada and the United States, recognized both species (in *Dicranum*). Later, Barnes (1958), at the University of Washington, compared the two, and concluded there were no consistent differences between them. No specimens or methodology were reported, so it is not known the provenance of or how many specimens she examined. Barnes's conclusions were endorsed by Lawton (1971), also at University of Washington, when she submerged *P. sauteri* within *P. longifolium* without comment for her Moss Flora of the Pacific Northwest. It is noteworthy that *P. sauteri* is so far unknown from Oregon, Washington, and Idaho, with only a few specimens from British

(Continued on page 2)

Botanice est Scientia Naturalis quae Vegetabilium cognitioem tradit.

— Linnaeus



(Continued from page 1)

Columbia, so it is possible that Barnes saw few, if any, true *sauteri* for her study.

Ireland (2007), within his *P. longifolium* treatment, discussed the reported differences between *longifolium* and *sauteri*, but concluded he could not confirm the differences from the few specimens of *sauteri* available to him, preferring to await further clarifying studies.

In contrast, Weber & Wittmann's (2007) account of the bryophytes of Colorado, in the Rocky Mountain region wherein *sauteri* is centered, recognized two clearly distinguishable species.

We examined 65 specimens of *Paraleucobryum* from New Mexico (see Appendix I), representing all known collections of the genus from the state (as reported in CNABH); 7 of these belonged to *P. enerve*. Of the remaining 58 specimens, all but 1 belonged to *P. sauteri*, based on features outlined in Table 1 and illustrated in Appendix II. The single remaining specimen (San Miguel County, K.W. Allred 11067, NMCR) was the only specimen of *P. longifolium* seen from the state. We also compared these with specimens of *P. longifolium* (Weber & Wittmann B-110595) and *P. sauteri* (Anderson 18 June 2021 s.n.) from Colorado, and *P. longifolium* from New York (Miller 13523). All specimens we have seen fit clearly the distinctions outlined in Table 1. We experienced no difficulty distinguishing two species. Based on this review of New Mexico material, we see no reason to consider combining the two species, as did Barnes (1958).

We were not able to locate the voucher for Müller & Frahm's (1987) report of *Paraleucobryum longifolium*.

Additional corroborating illustrations are presented in Appendix III.

Identification of New Mexico *Paraleucobryum*

Compared to similar species in Dicranaceae and Leucobryaceae, New Mexico specimens of *Paraleucobryum* may be identified as follows:

- 1 Costa broad, occupying $\frac{1}{2}$ to nearly all of the leaf base
 - 2 Dense clusters of tiny spindle-shaped brood bodies produced in axils of upper leaves; leaves 2-3 mm long **Brothera** (Leucobryaceae)
 - 2 Brood bodies absent; leaves 2-8 mm long
 - 3 Leaves mostly straight; costa in cross-section composed of a single adaxial band of clear cells, a central band of clear guide cells, and an abaxial band of thick-walled (stereid) cells..... **Campylopus** (Leucobryaceae)
 - 3 Leaves straight to strongly curved; costa in cross-section composed of a median band of partially chlorophyllose cells and a band of clear cells both abaxially and adaxially (*P. enerve*, *P. longifolium*)..... **Paraleucobryum**
- 1 Costa narrower, occupying $\frac{1}{3}$ or less of the leaf base
 - 4 Alar cells differentiated, inflated, hyaline or often orangish or brownish, often bi-stratose (unistratose in *Orthodicranum montanum* & *Paraleucobryum sauteri*)
 - 5 Costa filling $\frac{1}{4}$ to $\frac{1}{2}$ of leaf base; leaves mostly falcate-curving wet and dry (*P. sauteri*) **Paraleucobryum**
 - 5 Cost filling less than $\frac{1}{4}$ of leaf base; leaves various, falcate-curving, straight, coiled, or crisped
 - 6 Capsules erect, straight, smooth to wrinkled; alar region unistratose **Orthodicranum**
 - 6 Capsules inclined, curved, ribbed; alar region bistratose **Dicranum**
 - 4 Alar cells not differentiated, or if so, then uni-stratose(remaining genera of the Dicranaceae in New Mexico)

Paraleucobryum

- 1 Leaves \pm straight to weakly curving; costa occupying $\frac{3}{4}$ to nearly all of the lamina just above the base; leaf margins entire or with a few teeth at the apex..... ***P. enerve***
- 1 Leaves conspicuously and strongly curving to markedly falcate/circinate; costa occupying $\frac{1}{4}$ to $\frac{3}{4}$ of the lamina just above the base; leaf margins serrate in the distal half or more (sometimes difficult to ascertain because of leaf rolling)
 - 2 Costa narrow, occupying $\frac{1}{4}$ to $\frac{1}{2}$ of the lamina just above the base (sometimes slightly more), \pm smooth to weakly ridged abaxially in cross-section; chlorophyllose cells of the middle layer commonly about 2 times larger than the adjacent surface hyaline cells (cross-section) ***P. sauteri***
 - 2 Costa broad, occupying $\frac{1}{2}$ to $\frac{3}{4}$ of the lamina just above the base (sometimes slightly less or more), mostly strongly ridged abaxially in cross-section; chlorophyllose cells of the middle layer commonly about the same size or smaller than the adjacent surface hyaline cells ***P. longifolium***

[Descriptions adapted from Müller & Frahm 1987]

Paraleucobryum enerve (Thedenius) Loeske [nerveless] [*Campylopus albescens* Kindberg, *Campylopus albicans* Schwägrichen, *Campylopus candicans* Kindberg, *Campylopus crassinervis* Wilson, *Campylopus hallii* Lesquereux, **Dicranum enerve* Thedenius (basionym), *Dicranum albicans* Schwägrichen of 1850, *nom. illeg.*]. Plants in dense cushions or tufts, whitish to light green to sometimes deep green, the stems to 8(12) cm long/tall, commonly radiculose at the base; leaves erect to somewhat spreading, 4-5 mm long, narrowly lanceolate, the margins entire, the apices entire to rarely few-toothed; costa at leaf base 475-525



(Continued on page 3)

Botany is the natural science that transmits the knowledge of plants.

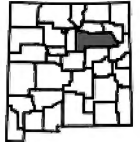
— Linnaeus



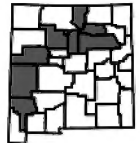
(Continued from page 2)

µm wide, filling $\frac{3}{4}$ to $\frac{4}{5}$ or more of the leaf base width, smooth abaxially, in cross-section with a single middle band of chlorophyllose cells, the adaxial and abaxial hyaline cells larger than the median cells and devoid of intercalary chlorophyllose cells; alar cells inflated, larger than the surrounding cells; proximal cells elongate, thin-walled, weakly pitted; setae (not known on NM material) yellowish to brownish, to 16 mm long/tall; capsules (not known on NM material) 2.5 mm long without operculum, cylindrical, smooth, the operculum rostrate. ●On thin soil over rocks and boulders, on loamy soil, typically alpine or upper subalpine mountainous regions, also lower elevations in compensating environments such as the ice caves at El Malpais National Monument. ♦Diagnostic features include the commonly straight or weakly curving leaves, exceedingly broad costa (appearing absent, hence the specific epithet) smooth abaxially, central chlorophyllose cells smaller than the adjacent hyaline surface cells, and lack of chlorophyllose cells interspersed among the hyaline surface cells.

Paraleucobryum longifolium (Ehrhart ex Hedwig) Loeske [long-leaved] [*Bryum longifolium* (Ehrhart ex Hedwig) Dickson, *Campylopus bartramii* Hampe, *Campylopus canadensis* Kindberg, *Campylopus longifolius* (Ehrhart ex Hedwig) Kindberg *nom. illeg.*, *Dicranodontium longifolium* (Ehrhart ex Hedwig) James, *Dicranodontium nitidum* T.P. James, **Dicranum longifolium* Ehrhart ex Hedwig (basionym)]. Plant in dense cushions or tufts, gray-green, light green, to full or dark green, the stems to 4(8) cm long/tall, commonly radiculose at the base; leaves usually strongly curved or falcate to circinate, 4-8 mm long, narrowly lanceolate, the margins and apices serrate in the upper $\frac{2}{3}$ to $\frac{1}{2}$; costa at leaf base 390-430 µm wide, filling $\frac{1}{2}$ to $\frac{2}{3}$ of the leaf base width, ridged abaxially, in cross-section with a single band of chlorophyllose cells, the adaxial and abaxial hyaline cells about the same size or larger than the median cells and with intercalary chlorophyllose cells; alar cells inflated, brownish-orangish, larger than the surrounding cells; proximal cells elongate, thin-walled, weakly pitted; setae 10-20 mm long/tall; capsules reddish brown to dark brown, 2-2.5 mm long without operculum, cylindrical, the operculum long-rostrate and about as long as the capsule; peristome teeth divided halfway and inserted at mouth. ●Known from verified specimens only from a single site in San Miguel County, on rock faces and outcrops; out-of-state occurring on thin soil over rocks and boulders, occasionally on bark or rotting wood. ♦Diagnostic features include the strongly curved leaves (sometimes only weakly so), costa of intermediate width and commonly ridged abaxially, central chlorophyllose cells smaller than (sometimes equal to) the adjacent hyaline surface cells, and chlorophyllose cells interspersed among the hyaline surface cells.



Paraleucobryum sauteri (Bruch & Schimper) Loeske [for Anton Eleutherius Sauter (1800-1881), an Austrian physician and botanist, author of *Flora des Herzogthums Salzburg*] [*Campylopus frigidus* Lesquereux, *Campylopus longifolius* (Ehrhart ex Hedwig) Kindberg subsp. *sauteri* (Bruch & Schimper) Kindberg *nom. illeg.*, *Campylopus sauteri* (Bruch & Schimper) Paris, *Dicranum longifolium* (Ehrhart ex Hedwig) Loeske subsp. *sauteri* (Bruch & Schimper) Kindberg, *Dicranum longifolium* (Ehrhart ex Hedwig) Loeske var. *sauteri* (Bruch & Schimper) Velenovsky, **Dicranum sauteri* Bruch & Schimper (basionym), *Paraleucobryum longifolium* (Ehrhart ex Hedwig) Loeske subsp. *sauteri* (Bruch & Schimper) C.E.O. Jensen, *Paraleucobryum longifolium* (Ehrhart ex Hedwig) Loeske var. *sauteri* (Bruch & Schimper) C.E.O. Jensen]. Plants in dense cushions or tufts, golden green, yellowish green, light green, to green, the stems 3-5 cm long/tall, brownish radiculose; leaves mostly strongly falcate to circinate, to 6 mm long, narrowly lanceolate, sometimes some leaves nearly straight or with broken tips, the margins and apices serrate/serrulate in the upper $\frac{1}{2}$; costa at leaf base 140-204 µm wide, filling $\frac{1}{4}$ to $\frac{1}{3}$ of the leaf base width, sometimes slightly wider but never as much as $\frac{1}{2}$ the leaf width, weakly to moderately ridged abaxially, in cross-section single band of chlorophyllose cells, the adaxial and abaxial hyaline cells smaller (at least some cells $\frac{1}{2}$ the size) than the median cells and with intercalary chlorophyllose cells abaxially; alar cells inflated brownish orangish to hyaline; proximal cells elongate, thick-walled, pitted; setae to 13 mm long/tall, yellowish; capsules reddish brown, cylindrical, 2-2.5 mm long without operculum, the operculum long and about as long as the capsule; peristome teeth divided nearly to the base and inserted below the mouth. ●Relatively common in the mountains of the state; on thin soil over rocks and boulders, bases of trees, moist loamy ground, rotting wood and stumps. ♦Diagnostic features include the strongly falcate/circinate leaves, costa of narrow width and weakly to moderately ridged abaxially, central chlorophyllose cells larger than the adjacent hyaline surface cells, and chlorophyllose cells interspersed among the hyaline surface cells. Infrequently, one finds clumps with numerous almost straight leaves mixed with curving/falcate leaves, or with numerous leaves of a shoot (up to 50%) with broken tips (for example, Kleinman 2018-4-16-40).



Acknowledgements

We thank Bruce Allen and John Brinda (MO) for their long-suffering and patient help with our questions and with early identifications as we began looking at *Paraleucobryum*. James Shevock (CAS) assisted by exchanging specimens of *Paraleucobryum* with us. Stacey Anderson and Ron Wittmann were especially helpful in sending Colorado specimens of *Paraleucobryum* for comparison. We also thank Kristian Peters and Herman Schachner for the use of their online photos for comparison. We extend special recognition and thanks to numerous herbarium curators and staff who have given access to their collections through online digital databases (Consortium of North American Bryophyte Herbaria, CNABH), which we consulted for this little inquiry: CAS, DUKE, FH, GH, MDKY, MICH, MO, NMCR, NY, RM, S, SNM, UBC, WTU. We particularly thank the following for their loans of actual specimens: DUKE, NY, GH; and Zach Rogers (NMC/NMCR) for arranging for these loans.

(Continued on page 4)



(Continued from page 3)

Literature Cited

- Allred, K.W. 2011. Mosses of New Mexico (checklist). The New Mexico Botanist 55: 1-10.
- Allred, K.W., R. Kleinman, & K. Blisard. 2018. Preliminary Guide to the Bryophytes of New Mexico [an incomplete work in progress]. lulu.com. 120 pp.
- Barnes, C. 1958. The genus *Paraleucobryum*. The Bryologist 61: 335-339.
- Bartram, E.B. 1931. Mosses of northern New Mexico collected by Bro. Arsène. Annales de Cryptogamie Exotique, Paris 4: 153-160.
- Darigo, C.E. & K.W. Allred. 2001. Mosses of New Mexico — County checklist. Evansia 18(1): 1-18.
- Hallingbäck, T., N. Lönnell, H. Weibull, L. Hednäs, & P. von Knorring. 2006. Nationalnyckeln till Sveriges flora och fauna. Bladmossor: Sköldmossor – blåmossor. Bryophyta: *Buxbaumia* – *Leucobryum*. ArtDatabanken, SLU, Uppsala.
- Ireland, R.R. Jr. 1994. *Paraleucobryum*. IN: Sharp, A.J., H. Crum, & P.M. Eckel (eds.). The Moss Flora of Mexico, part 1. Memoirs of the New York Botanical Garden 69(1): 147-148.
- _____. 2007. *Paraleucobryum*. IN: Flora of North America Editorial Committee, eds. 1993+. Flora of North America North of Mexico. Vol. 27: 425-428.
- La Farge, C., B.D. Mishler, J.A. Wheeler, D.P. Wall, K. Johannes, S. Schaffer, & A.J. Shaw. 2000. Phylogenetic relationships within the haplolepidous mosses. The Bryologist 103(2): 257-276.
- _____, A.J. Shaw, & D.H. Vitt. 2002. The circumscription of the Dicranaceae (Bryopsida) based on the chloroplast regions *trnL*—*trnF* and *rps4*. Systematic Botany 27(3): 435-452.
- Loeske, L. 1907. *Dicranum*, sectio *Paraleucobryum*. Allgemeine Botanische Zeitschrift für Systematik, Floristik, Pflanzengeographie 13: 162.
- Mahler, W.F. 1978. Preliminary checklist of mosses of New Mexico. The Bryologist 81(4): 593-599.
- Müller, P. & J.-P. Frahm. 1987. A review of the Paraleucobryoideae (Dicranaceae). Nova Hedwigia 45(3/4): 283-314.
- Stech, M. 1999. A reclassification of Dicranaceae (Bryopsida) based on non-coding cpDNA sequence data. The Journal of the Hattori Botanical Laboratory 86: 137-159.
- Weber, W.A. & R.C. Wittmann. 2007. Bryophytes of Colorado. Pilgrims Process, Inc., Santa Fe, New Mexico.
- Williams, R.S. 1913. Dicranaceae. IN: North American Flora, New York Botanical Garden 15(2): 77-158.

Table 1: Important features of *Paraleucobryum* species in New Mexico.

	<i>P. enerve</i>	<i>P. sauteri</i>	<i>P. longifolium</i>
leaf orientation	straight to slightly curved	falcate/circinate	falcate/circinate
leaf margins	± entire	serrulate upper ½ to entire	serrate upper ⅔ - ½
leaf apices	± entire	weakly serrate	serrate
lamina longitudinally free from costa	about ⅓ or less of leaf length	about ¼ - ½ of leaf length	about ⅓ - ¼ of leaf length
costa width	¾ - 9/10 of leaf base	¼ - ⅓ of leaf base	½ - ¾ of leaf base
costa abaxial surface	smooth	weakly to moderately ridged	strongly ridged
central chlorophyllose cells	mostly smaller than adjacent hyaline cells	mostly larger than adjacent hyaline cells	mostly smaller than or equal to adjacent hyaline cells
abaxial chlorophyllose cells	absent	intermixed with hyaline cells	intermixed with hyaline cells
elevation of collections (ft)	(7420) 9800-11900	7450-10500	7833

Appendix I: Verified Specimens

Paraleucobryum enerve (7): Cibola County: Grants Lava Bed [El Malpais National Monument], in 1947, *A. Lindsey 6a* (FH); Grants Lava Bed [El Malpais National Monument], Aug 1948, *A. Lindsey 3* (FH). San Miguel County: Sangre de Cristo Mtns, Hermit's Peak, 3000 m, 7 Sept 1926, *Br. G. Arsene 18473* (FH). Sandoval County: Valles Caldera National Preserve, Redondo Mt, near peak, La Jara Creek, N35°52.6284' W106°32.9943', subalpine coniferous forest, 10700 ft, 31 Oct 2006, *Kelly W. Allred 9817* (NMCR). Santa Fe County: Santa Fe National Forest, Sangre de Cristo Mtns, Tesuque Peak, end of road to radio towers from Aspen Vista Picnic Area, on granite in subalpine zone, N35.7855556° W105.7813889°, 11900 ft, 10 Aug 2000, *Jonathan Shaw 11523* (DUKE, MDKY, MO, S). Taos County: Sangre de Cristo Mtns, Carson National Forest, Taos Ski Valley, end of Twining/Kachina Road near start of Wheeler Peak Trail, subalpine mixed conifer forest, on soil in partial shade, N36.577465° W105.437595°, 10200 ft, 17 Sept 2017, *Russ Kleinman & Karen Blisard 2017-9-17* (SNM); Sangre de Cristo Mts, around Twining, Taos Ski Basin, end of Kachina Road near Bavarian Restaurant, N36.576728° W105.438196°, 10220 ft, on vertical boulder face in partial shade, 3 Aug 2017, *Kelly W. Allred 11012* (NMCR).

(Continued on page 5)



(Continued from page 4)

Paraleucobryum longifolium (1): San Miguel County: Santa Fe Mts, Santa Fe National Forest, Gallinas Canyon, along Forest Road 263, along Gallinas Creek, between Big Pine Picnic Site and Baker Flat Picnic Site, mixed conifer forest, N35.71061° W105.45553°, 7833 ft, on moist thin soil of cliff faces and outcrops just south of creek, partial shade, mixed with *Pseudoleskeella arizonae*, 15 July 2021, *Kelly W. Allred 11067* (NMCR).

Paraleucobryum sauteri (57): Catron County: Mogollon Mts, on or near the West Fork of the Gila River, approx. 7500 ft, 13 Aug 1903, *O.B. Metcalfe 468* (DUKE); Gila National Forest, Iron Creek, mixed conifer forest, N33°22.629' W108°33.429', growing on forest litter in partial shade, 7830 ft (2387 m), 7 June 2000, *Kelly W. Allred 7779* (NMCR); Gila National Forest, campsite just east of Ben Lily Campground, along Willow Creek, mixed conifer forest with spruce, ponderosa, douglas fir, alder along the creek, N33°23.73' W108°35.64', growing on rocks, 8100 (2500 m), 13 Aug 1999, *Kelly W. Allred 7621* (NMCR); Mogollon Range, 9100 ft, 3 June 1964, *Michael Baad 1382* (MICH). Cibola County: Grants Lava Bed [El Malpais National Monument], in 1947, *A. Lindsey s.n.* (GH); El Malpais National Monument, Brewer's Cave (Pantheon) a 50 foot rappel into collapsed lava tube cave, 34.919532 -102.076077, mixed conifer forest, on volcanic boulder, moist, in partial shade, 7426 ft, 24 May 2019, *Russ Kleinman 2019-5-24-13, 2019-5-24-21, 2019-5-24-14a,b, 2019-5-24-19, 2019-5-24-16E, 2019-5-24-17* (SNM); El Malpais National Monument, Fern Sink (cave 090) a 50 foot rappel into collapsed lava tube cave entrance, 34.945246 -102.113302, on fallen, dead, rotten tree trunk, 7755 ft, 23 May 2019, *Russ Kleinman 2019-5-23-9* (SNM); El Malpais National Monument, Big Skylight Cave, 34.945554 -108.101272 NAD 83, on volcanic boulder, 7647 ft, 5 Nov 2016, *Russ Kleinman 2016-11-5-11, 2016-11-5-13* (SNM); El Malpais National Monument, Entrance Ice, Cave 92, off Forest Road 300, 34.936924 -108.109785 NAD 83, on basalt, 7582 ft, 20 July 2016, *Russ Kleinman 2016-7-20-24, 2016-7-20-27* (SNM); El Malpais National Monument, Flint's Hideout (174), 34.893849 -108.0194 WGS84, on wood, 7500 ft, 13 Mar 2017, *Laura Baumann 2017-03-13-1* (SNM); El Malpais National Monument, Outlaw System #038, Eagle's Nest Skylight, 34.899567 -108.037572 WGS84, on rock, 7400 ft, 8 Mar 2017, *Laura Baumann 2017-3-8-1* (SNM); El Malpais National Monument, Classic Cave (cave #24) at entrance, 34.927613 -108.080759 NAD83, on moist rock, 7437 ft, 27 Feb 2017, *Laura Baumann 2017-2-27-3, 2017-2-27-4* (SNM); El Malpais National Monument, Four Windows Cave, on volcanic boulder, 7650 ft, 5 Nov 2016, *Laura Baumann 2016-11-5-58* (SNM); El Malpais National Monument, Big Skylight Cave, 34.945554 -108.101272 NAD83, on downed trunk, 7647 ft, *Laura Baumann 2016-11-5-34.5, 2016-11-5-38, 2016-11-5-39* (SNM); El Malpais National Monument, Tube Dweller Cave entrance, on lava rock, 7618 ft, 17 Apr 2018, *Russ Kleinman 2018-4-17-11* (SNM); El Malpais National Monument, Classic Cave (cave #24), skylight, 34.927613 -108.080759, NAD 83, 7437 ft, 16 Apr 2018, *Russ Kleinman 2018-4-16-2, 2018-4-16-3, 2018-4-16-6, 2018-4-16-8, 2018-4-16-12, 2018-4-16-13, 2018-4-16-19, 2018-4-16-40* (SNM); El Malpais National Monument, Fayó Cave 32, on lava rock, 7500 ft, 19 Apr 2017, *Russ Kleinman 2017-4-19-28, 2017-4-19-32* (SNM); El Malpais National Monument, Navajo Ice Cave (cave #29), 34.913863 -108.068991, NAD 83, on lava rock, 7450 ft, 19 Apr 2017, *Russ Kleinman 2019-4-19-4* (SNM); Grants Lava Bed [El Malpais National Monument], in 1947, *A. Lindsey s.n.* (FH); El Malpais National Monument, west side of monument, south of Big Tubes Area, Cave 92 Ice entrance, ponderosa pine, pinyon, juniper, Gambel oak, N34.93655° W108.11035°, on moist boulders in partial shade, 7590 ft, 20 July 2016, *Kelly W. Allred 10761.1* (NMCR); El Malpais National Monument, Navajo Ice Cave #29, N34.913826° W108.06895°, 7450 ft, on moist cave floor in partial shade, 19 April 2017, *Kelly W. Allred 10814* (NMCR); El Malpais National Monument, west side of monument, TJ's Turnaround Cave 457, ponderosa pine, pinyon, juniper, Gambel oak, moist boulders and outcrops in partial to full shade, 7800 ft, 21 July 2016, *Kelly W. Allred 10765* (NMCR); El Malpais National Monument, Classic Cave, ponderosa, pinyon, juniper, *Ribes*, about 2 air miles south of Lost Woman Crater, N34.92765° W108.08102°, 7513 ft, at mouth of cave, on moist soil over boulders in shady sites, 16 April 2018, *Kelly W. Allred 10930* (NMCR); El Malpais National Monument, Classic Cave Skylight, about 2 air miles south of Lost Woman Crater, ponderosa, pinyon, juniper, *Ribes*, N32.92764° W108.08099°, 7513 ft, on rocks beneath the skylight, in partial shade, 16 April 2018, *Kelly W. Allred 10934* (NMCR); El Malpais National Monument, Classic Cave Skylight, about 2 air miles south of Lost Woman Crater, ponderosa, pinyon, juniper, *Ribes*, N32.92764° W108.08099°, 7513 ft, on rocks beneath the skylight, in partial shade, 16 April 2018, *Kelly W. Allred 10940* (NMCR). Grant County: Upper Snow Creek, 17 Aug 1938, *L.N. & L.E. Goodding 102* (NY). Mora County: Sangre de Cristo Mountains, Pecos Wilderness, along trail 25 near Albright Creek, approximately N35.8473° W105.6440°, mixed coniferous forest, on rock, 9500 ft (2900 m), 31 July 1997, *Kelly W. Allred 6948* (NMCR). Sandoval County: Along hwy 126 about 24 miles east of Cuba and about 1 mile north of Calaveras Canyon, R2E T20N section 22, N35°56'30" W106°43'30", 8450 ft, in mixed fir and quaking aspen forest among volcanic rock outcrops, on rock wall, 16 Aug 2001, *James R. Shevock 21089* (CAS, NMCR); [Jemez Mountains, Santa Fe National Forest], along forest road 106, Water Canyon about 2 miles from highway 4, R3E, T19N, section 4, Lat/Long: N35°54'00" W106°38'00", 8300 ft, mixed fir and quaking aspen forest above a streamlet and stringer meadow, on volcanic boulders and rock outcrops, 16 Aug 2001, *James R. Shevock 21119* (CAS, NMCR); Jemez Mts, Santa Fe National Forest, East fork of the Jemez River, where hwy 4 crosses the river, about 22 road miles from Los Alamos, N35°49.645' W106°35.310', mixed conifer subalpine forest, mats on the rocky outcrops near the stream, 8000 ft (2430 m), 9 Aug 2003, *Kelly W. Allred 8881* (NMCR); Valles Caldera National Preserve, found on rocks in a felsenmeer near the peak of Cerro Rubio. with an aspect of 252°, a slope of 65%, abundance in 1m² 2%, found on boulder, in a dry microsite, WGS 84 Zone 13 N Easting 373334 Northing 3978741, 3090 m, 12 June 2009, *Kirsten Romig 17* (NMCR). San Miguel County: Lake Peak, 3784 m, 3 Oct 1926, *Br. Arsene 18626* (GH); Santa Fe National Forest, about 1.2 miles west of Cowles on Forest Road 121, Winsor Creek trailhead, subalpine mixed conifer forest, thick mats on rock, N35°49.0' W105°40.8', 8535 ft (2600 m), 28 June 2000, *Kelly W. Allred 7790* (NMCR); Santa Fe National Forest, Pecos Wilderness, Hwy 263 west of Las Vegas, Upper Gallinas Canyon, 35.712077 -105.481115 NAD 83, along creek on north-facing rock ledges in mixed conifer forest, 8282 ft, 13 Aug 2018, *Russ Kleinman 2018-8-13-3* (SNM). Santa Fe County: Sangre de Cristo Mts, Santa Fe Ski Basin, area around Aspen Basin Campground, subalpine

(Continued on page 6)

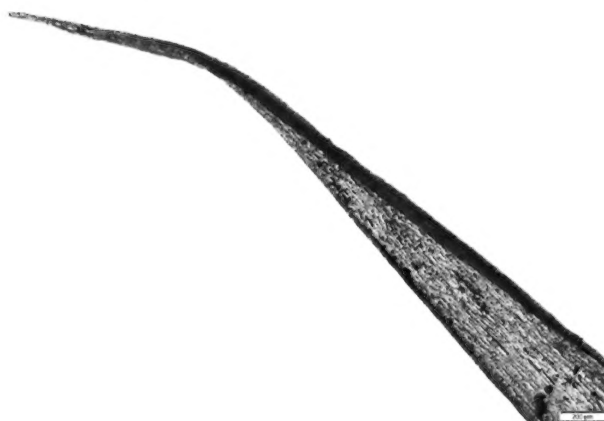
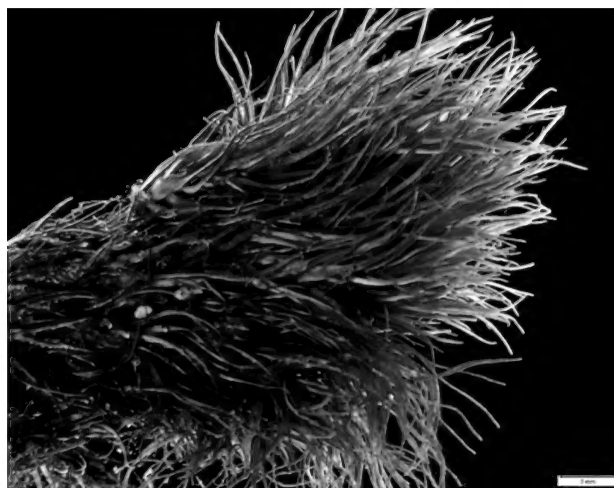


(Continued from page 5)

coniferous forest, N35.79538° W105.80167, 10326 ft, patch about 8-10 cm dia on dry granitic boulder in partial sun, 26 May 2021, *Kelly W. Allred 11008* (NMCR). Taos County: Sangre de Cristo Mts, west slope of Wheeler Peak, 17 miles nne of Taos, N36.56425° W105.37743°, 10500 ft, 16 July 1971, *Frederick J. Hermann 23982* (DUKE); Sangre de Cristo Mts, around Twining, Taos Ski Basin, end of Kachina Road near Bavarian Restaurant, N36.576728° W105.438196°, 10220 ft, on vertical boulder face in partial shade, 3 Aug 2017, *Kelly W. Allred 11013* (NMCR); Sangre de Cristo Mountains, Carson National Forest, Taos Ski Valley, end of Twining/Kachina Road near start of Wheeler Peak Trail, 36.577465 -105.437595, on decaying log and litter, subalpine mixed conifer forest, 10220 ft, 17 Sept 2017, *Russ Kleinman 2017-9-17-6a,b* (SNM).

Appendix II: Illustrations of New Mexico *Paraleucobryum* (photos by Allred & Kleinman)

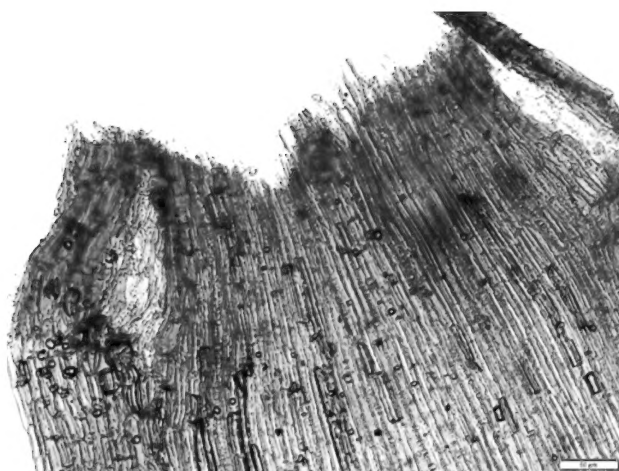
Paraleucobryum enerve



(Continued on page 7)



(Continued from page 6)



20 μm



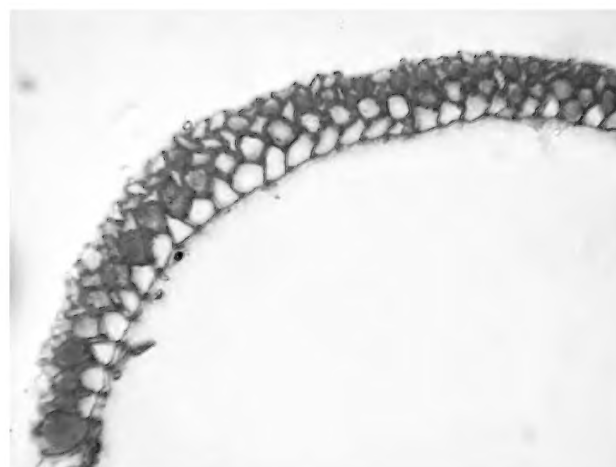
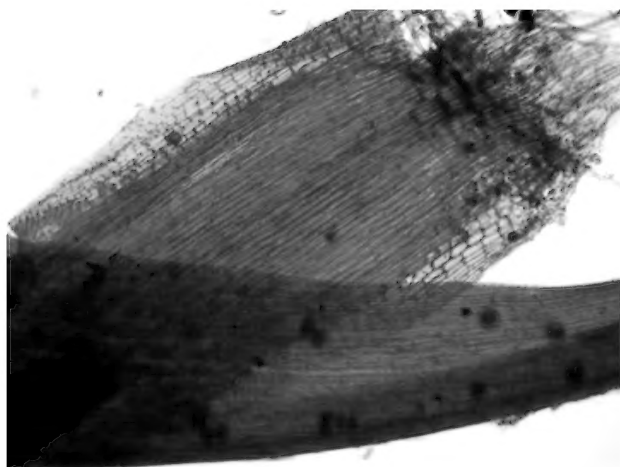
Paraleucobryum longifolium



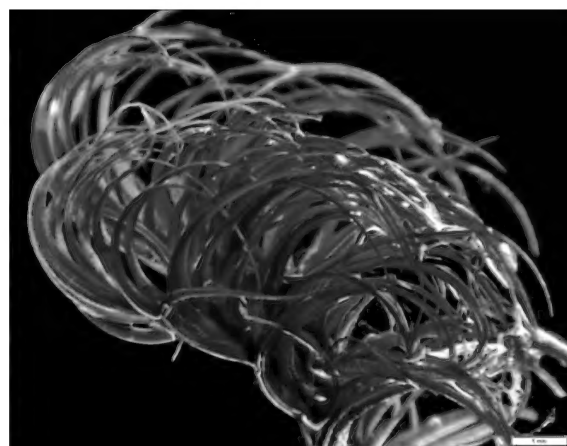
(Continued on page 8)



(Continued from page 7)



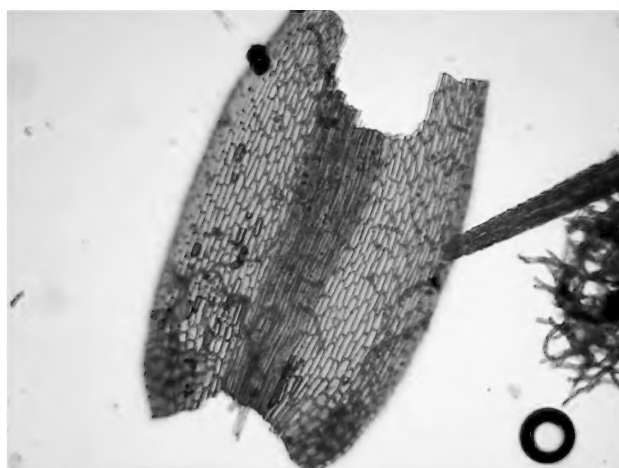
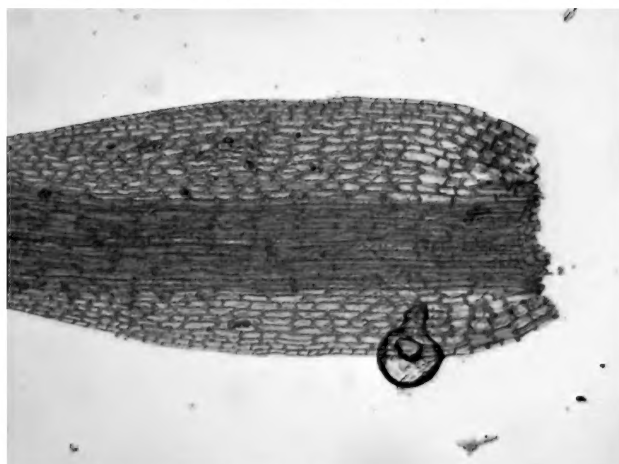
Paraleucobryum sauteri



(Continued on page 9)



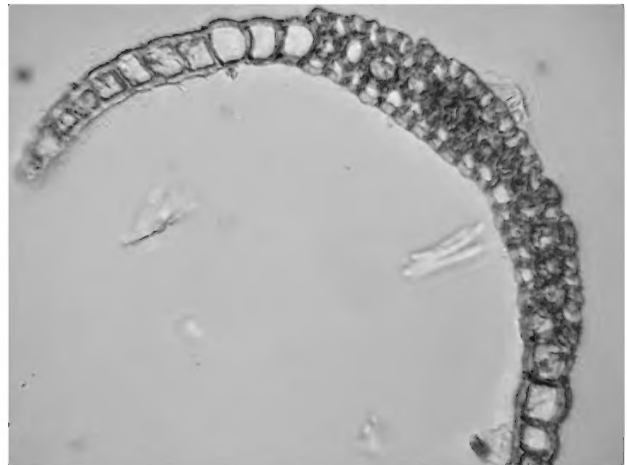
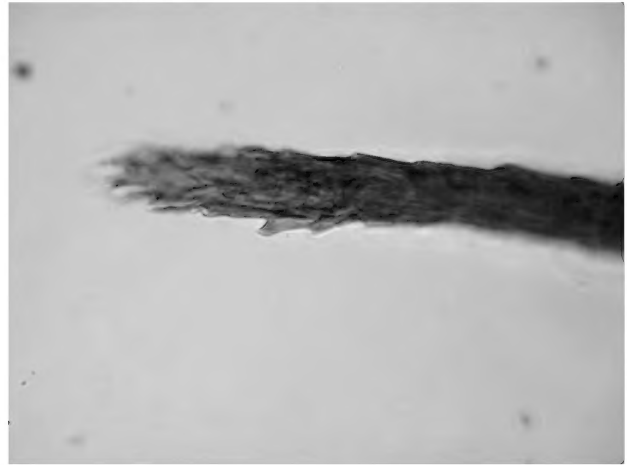
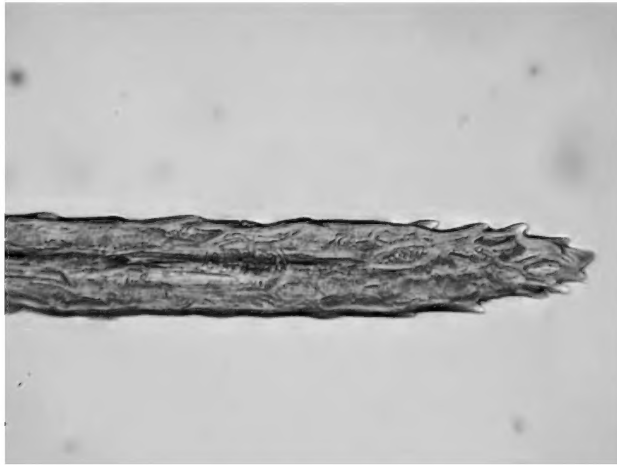
(Continued from page 8)



(Continued on page 10)



(Continued from page 9)



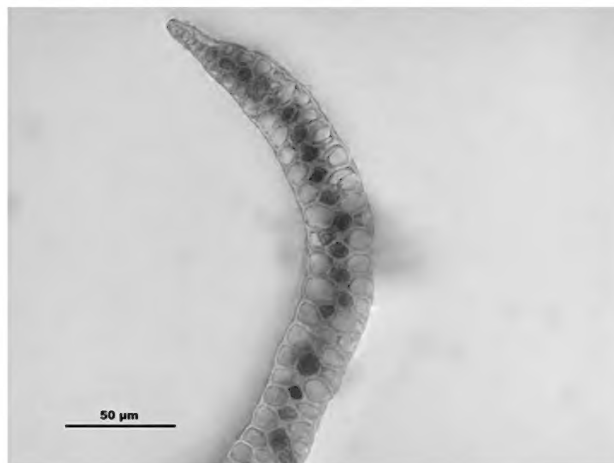
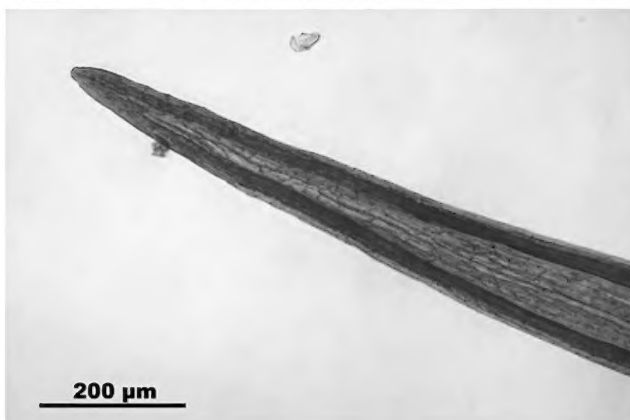
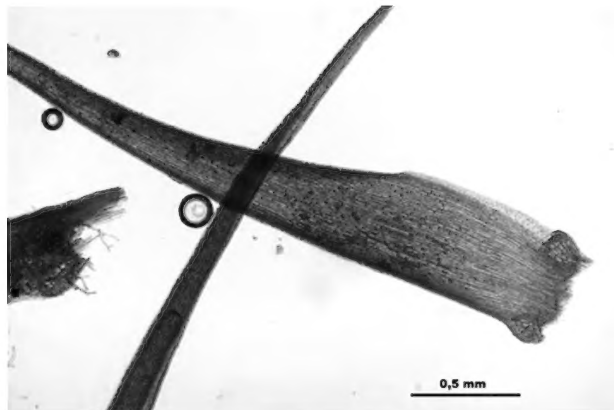
(Continued on page 11)



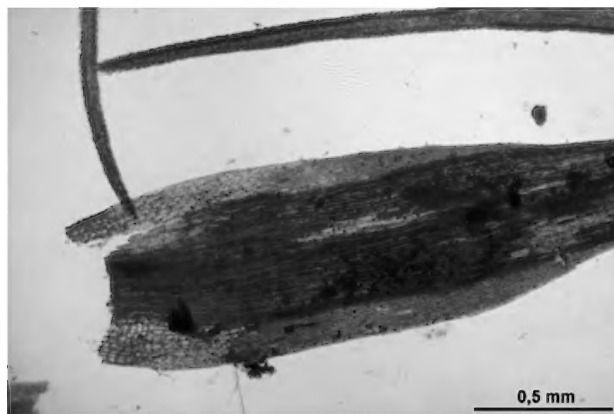
(Continued from page 10)

Appendix III: Corroborating illustrations courtesy of Herman Schachner (HS) and Kristian Peters (KP)

***Paraleucobryum enerve* (HS)**



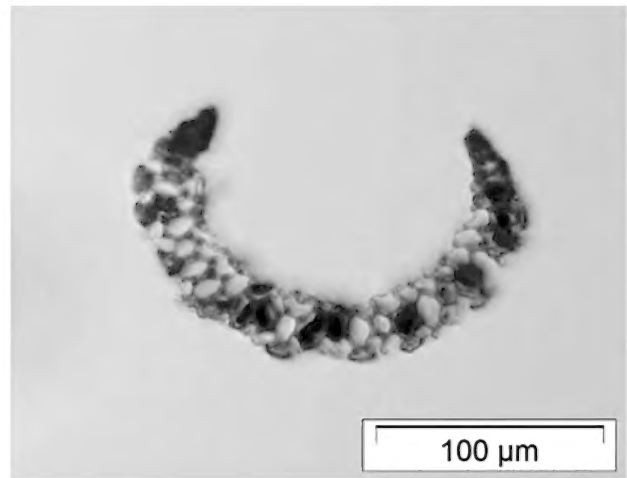
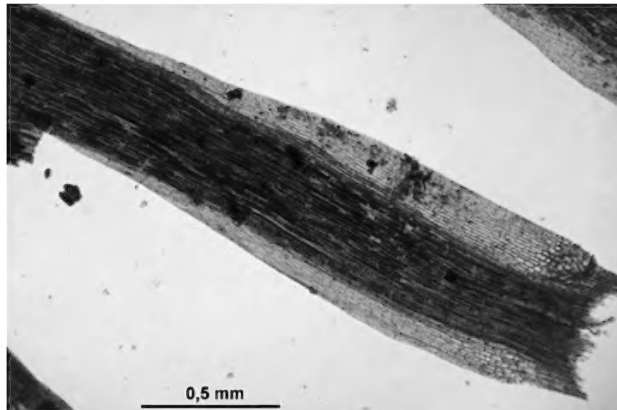
***Paraleucobryum longifolium* (HS)**



(Continued on page 12)



(Continued from page 11)



Paraleucobryum sauteri (KP)

